The Evaluation of End-of-Repair/End-of-Maintenance Dates for Electronic Assemblies

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Problem Description

- Electronic systems consist of multiple cards each containing multiple parts
- Many parts become obsolete long before the system support is terminated
  - Obsolete: can no longer be procured from the original vendor
- When obsolete parts are needed to repair the cards, they are drawn from inventories that may not be replenishable
- When all the parts and spare cards have been consumed, the cards may no longer be supportable

How long can legacy systems drawing from existing non-replenishable inventories of parts and cards be sustained?

End of Repair (EOR) and End of Maintenance (EOM) Definitions

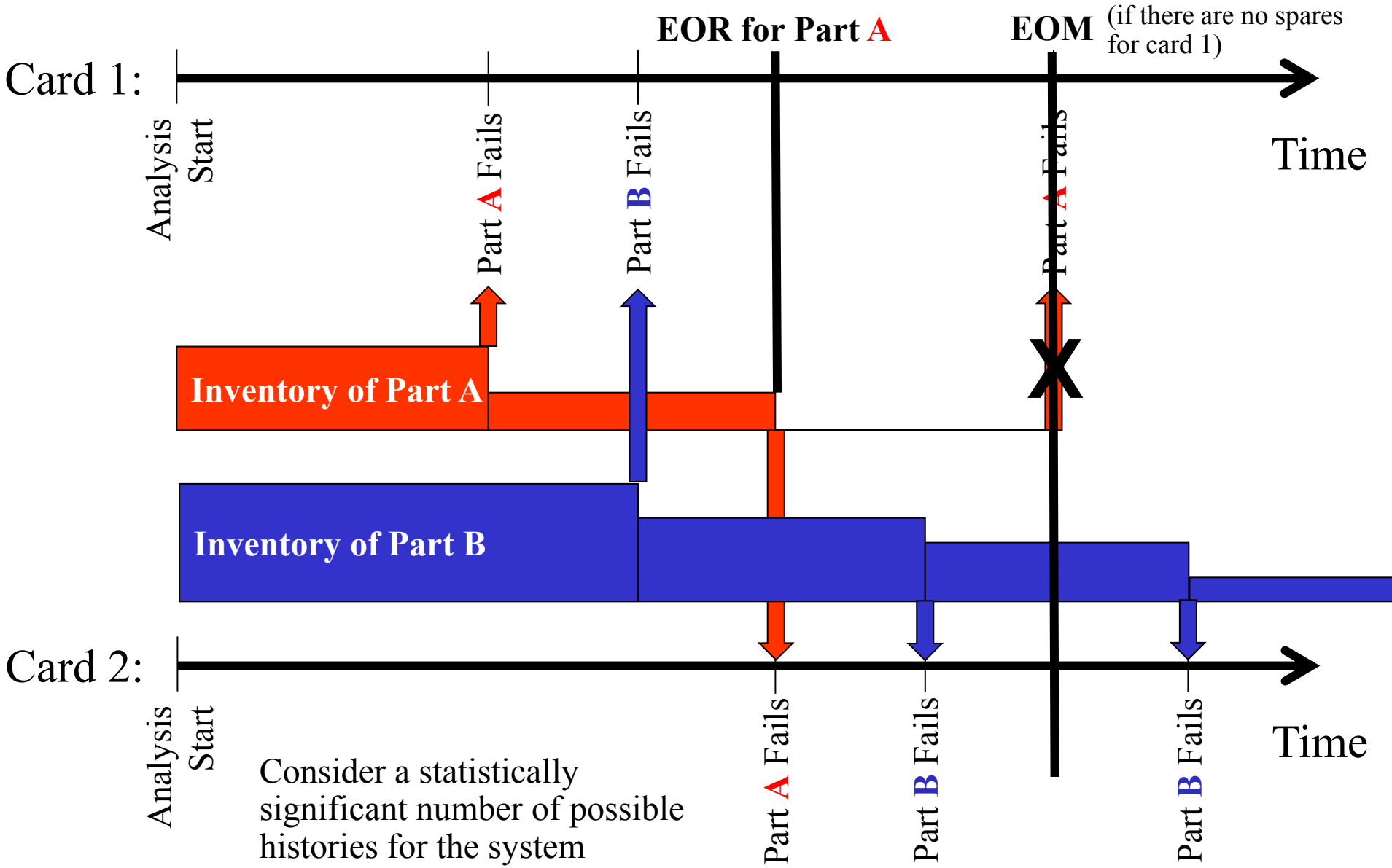
- *End of Repair* (EOR): The date that the last repair or manufacturing action associated with a part can be successfully performed.
  - EORs are part-specific
  - EORs may be part and card specific if specific cards can only draw parts from specific inventories

- *End of Maintenance* (EOM): The earliest date that all available inventories fail to support the demand for one or more specific parts resulting in the loss of system operation
  - EOMs are calculated for systems
  - System EOM is caused by a specific part on a specific card

Approach

- Use a stochastic discrete event simulator to track all instances of all parts in the system until repair requests cannot be fulfilled
  - Discrete event simulator: models a time line
  - Stochastic: variables can be represented using probability distributions
- Part-specific failure distributions are sampled to obtain failure dates for all parts on all cards
- When parts fail, replacements are drawn from existing inventories until the inventories are exhausted
- When the part inventories are exhausted spare cards (if any exist) are drawn until they are exhausted
- When new spare parts and cards are exhausted, parts harvested from replaced cards may optionally be drawn

Approach (continued)



Inputs and Outputs

Inputs:

- Card BOMs (Bills of Materials)
- Existing inventories of parts and cards
- Fielded systems descriptions (fielding and retirement dates, quantities, ...)
- Analysis data (start and end dates, operational hours/yr, …)
- Observed or predicted failure data (per part per card)

Outputs:

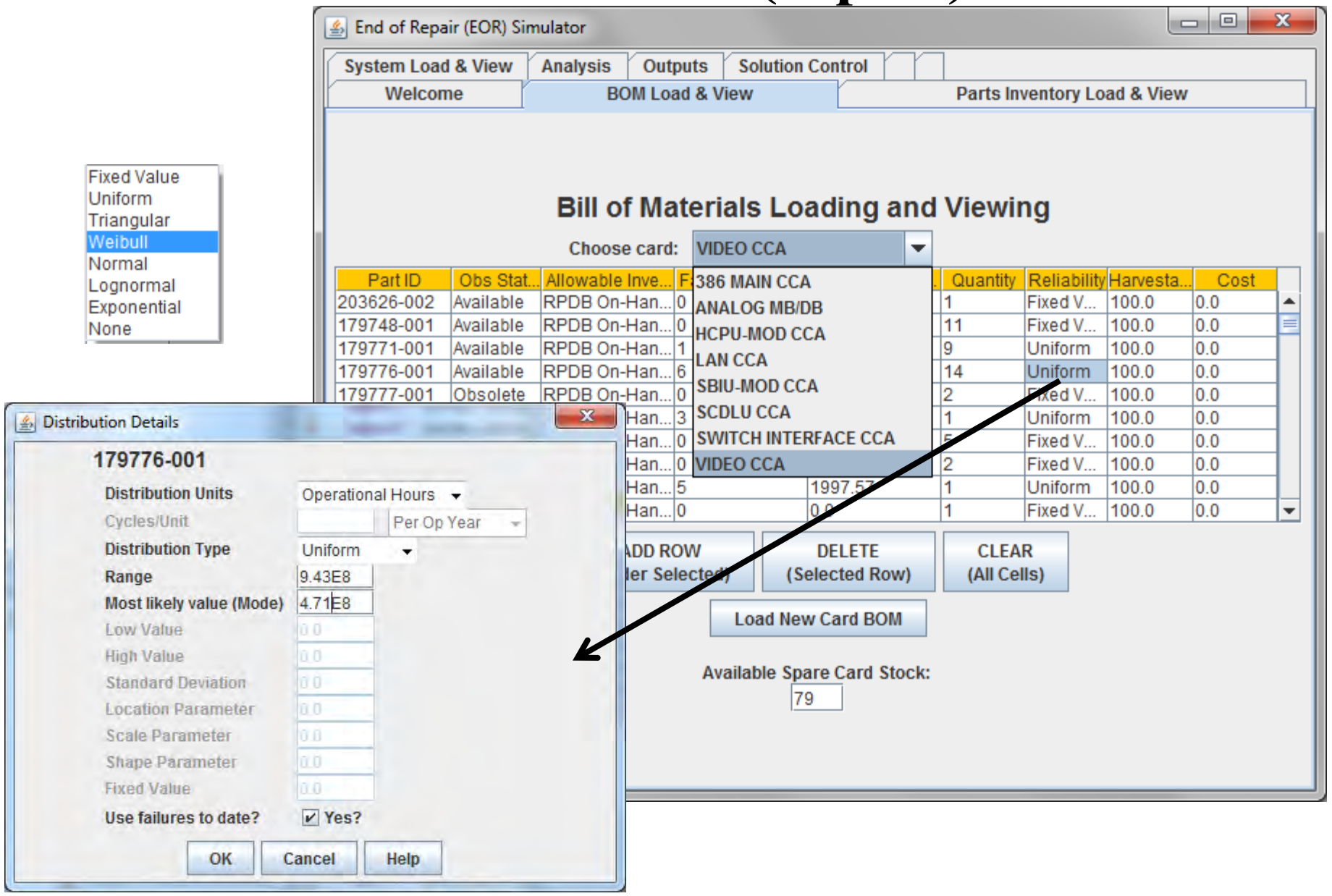
- Probability distributions of EOM and EOR dates
- Card-specific and part-specific probabilities of being the cause of EOM and EOR
- Loss of system functionality over time

Demonstration

This demonstration analyzes the following set of cards:

Item Description	Fielded Qty	Total Depot Inventory	BOMs
SCLDU CCA	33523	363	764500-02 764500-03
SWITCH INTERFACE CCA	3573	42	203616-G07 203616-G06
VIDEO CCA	3573	79	203625-G01
LAN CCA	3625	54	207364-G07
386 MAIN CCA	3573	96	215986-G07
ANALOG MB/DB	3573	135	216103-G09 (MB/DB) 216100-G02 (DB) 215955-G09 (MB) 215955-G10 (MB) 215955-G11 (MB)
HCPU-MOD CCA	1299	56	218758-G07 763371-04 763371-05
SBIU-MOD CCA	1867	55	218759-G05 763500-04 763500-05 763500-06

Demonstration (Inputs)



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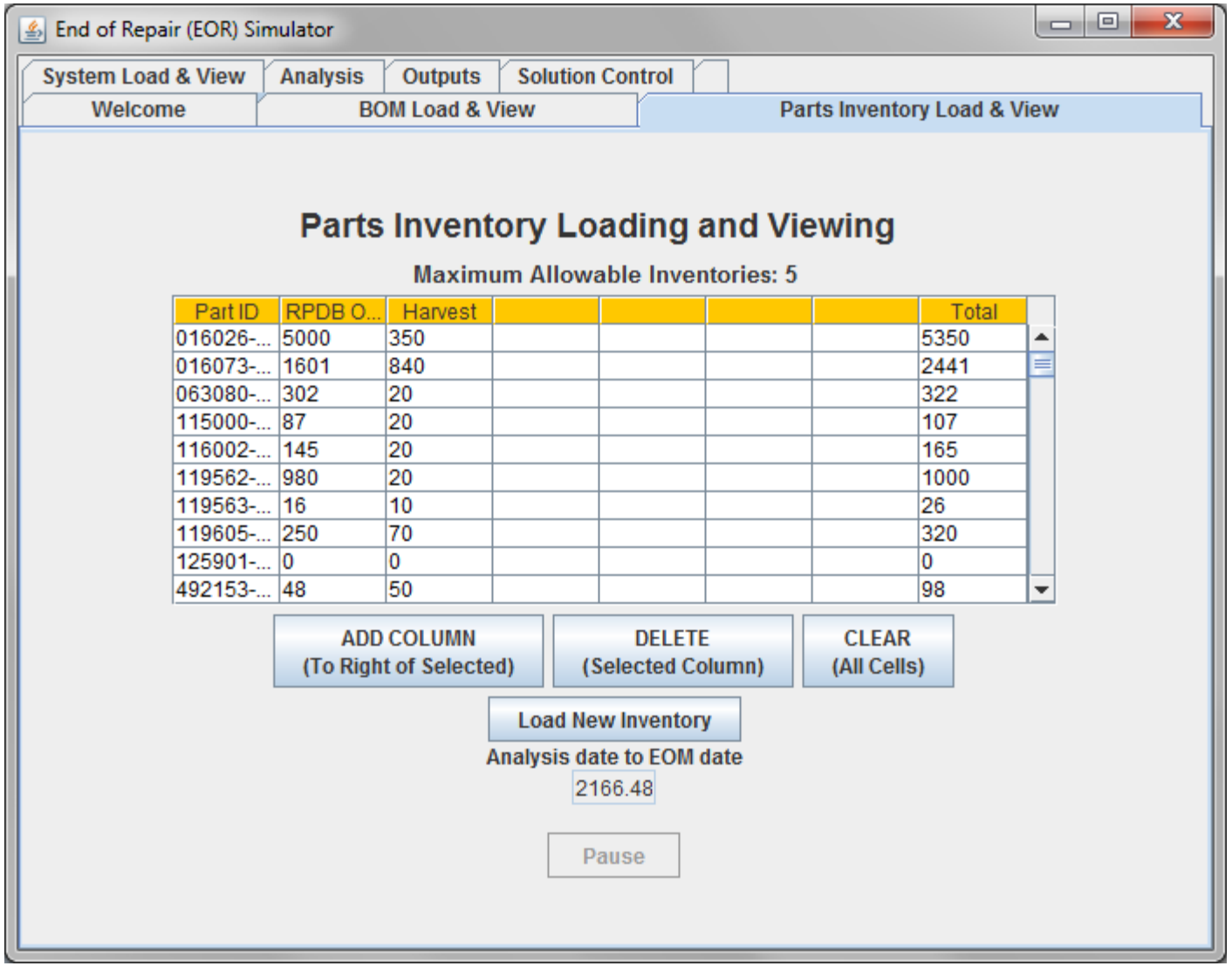

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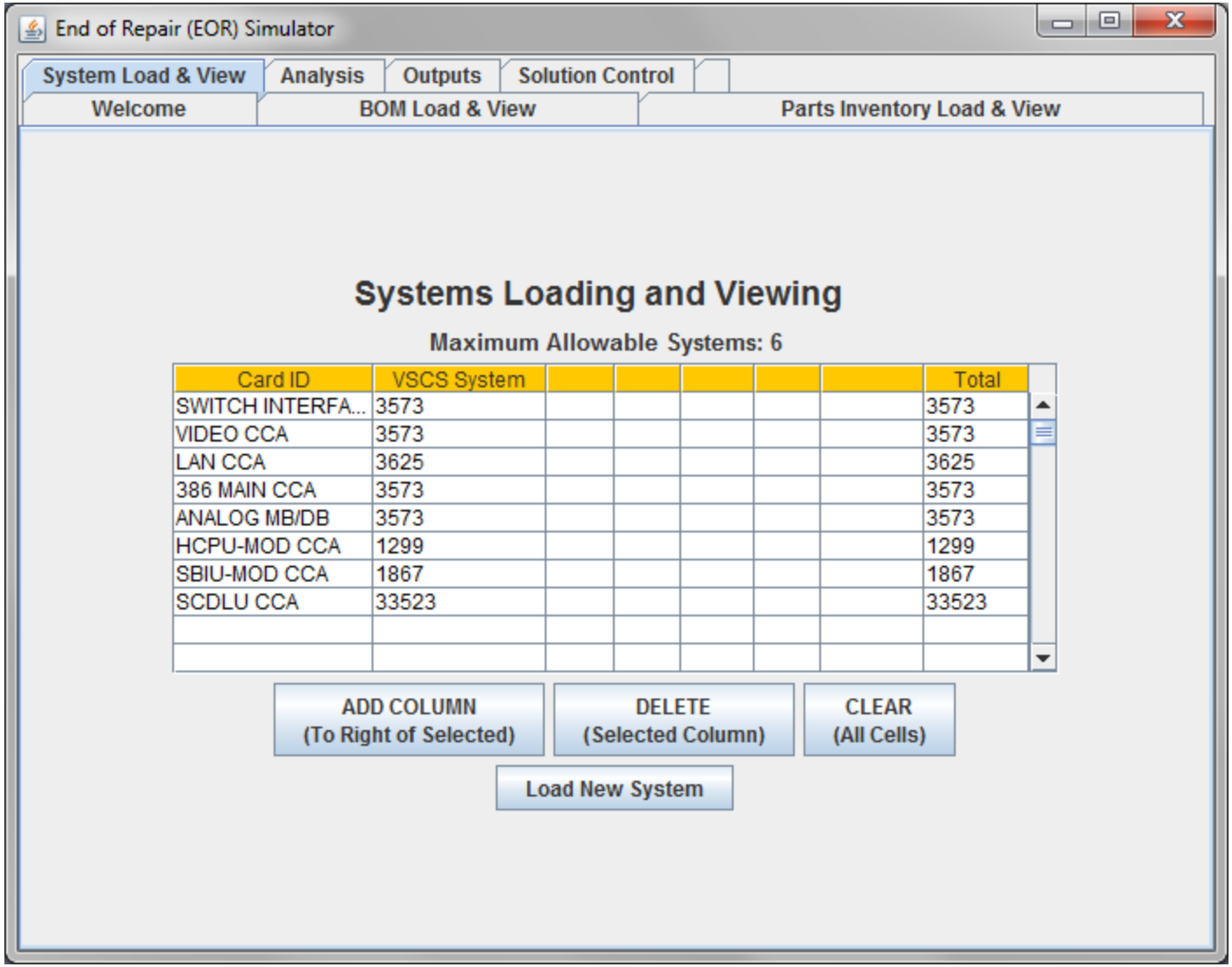

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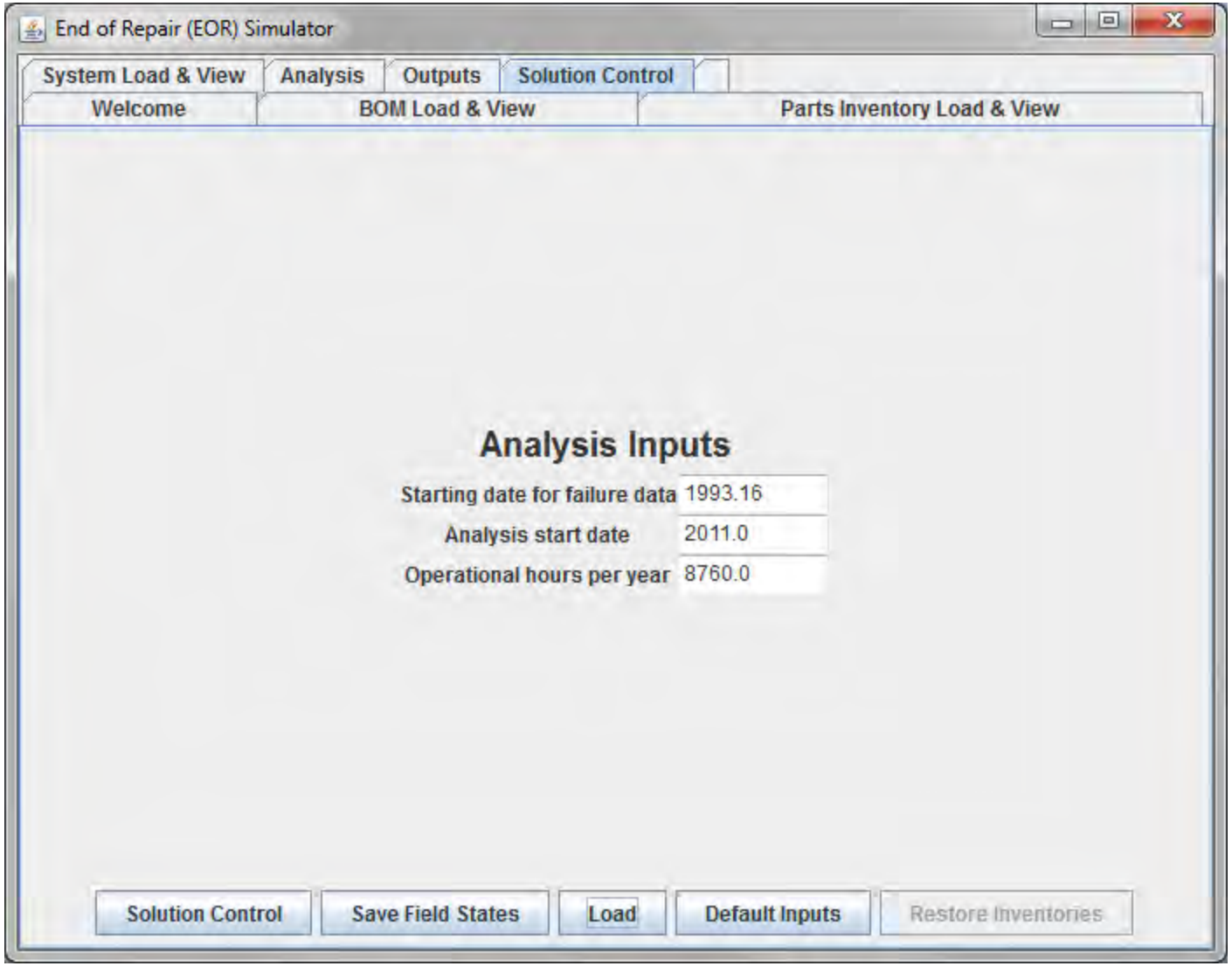
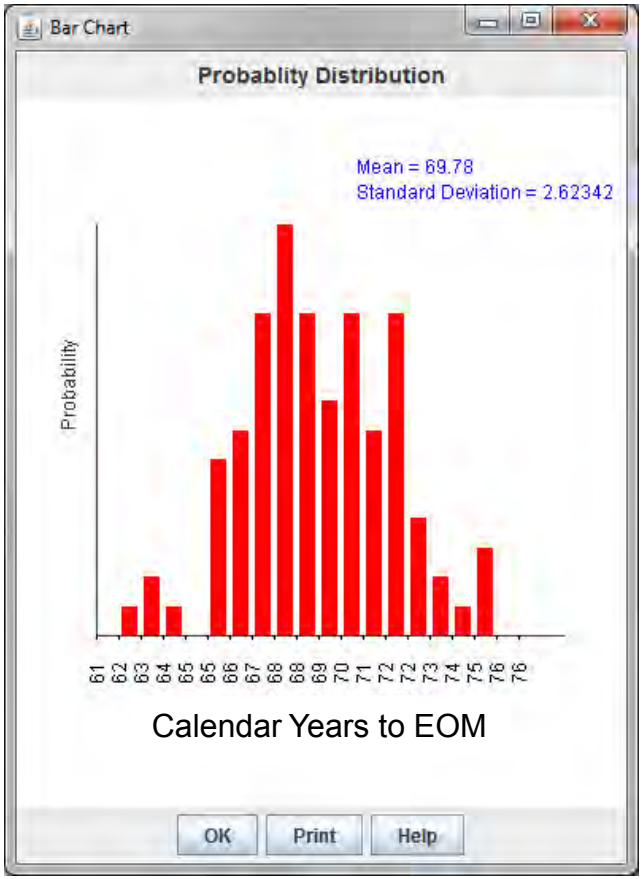


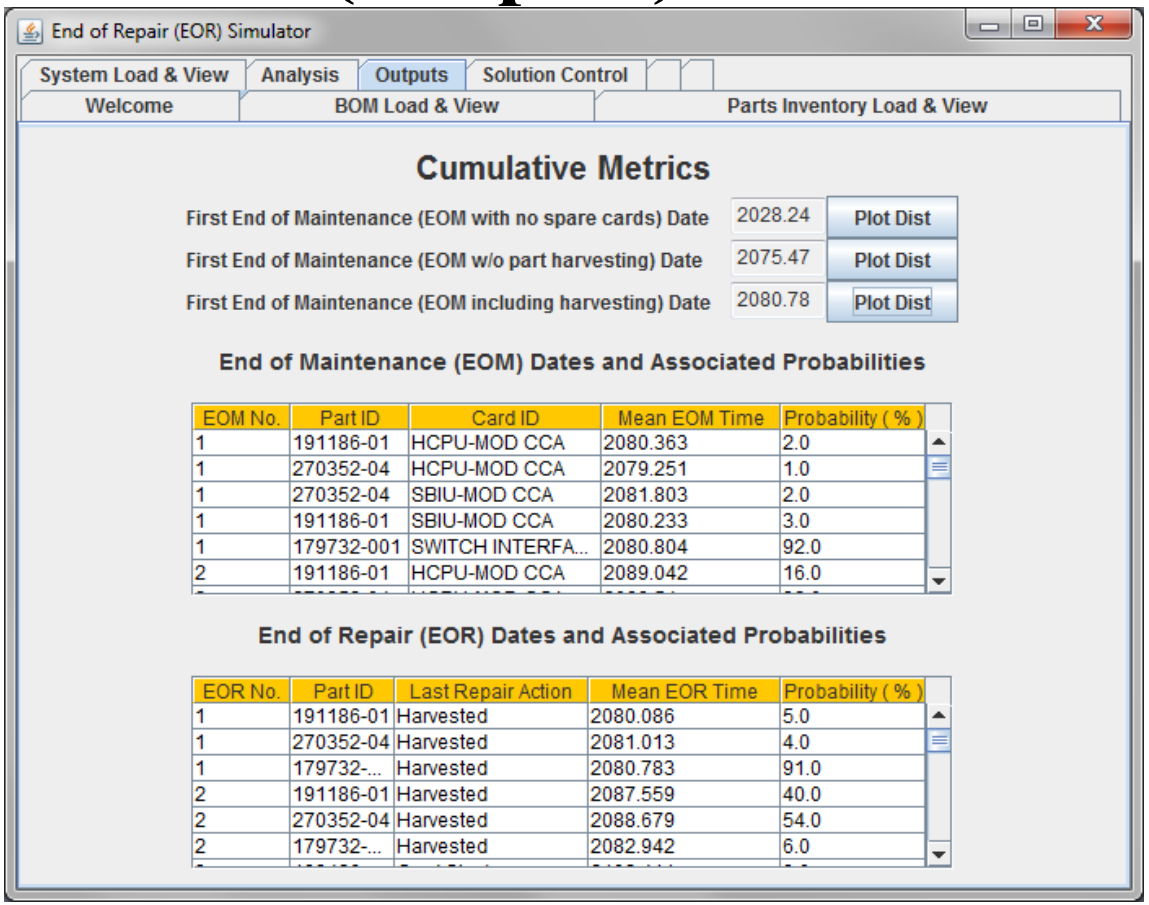
This is a Large "Bookkeeping" Problem

- Every instance of every part on every board is effectively modeled independently
  - Multiple instances of parts on cards accounted for
  - Multiple instances of cards in systems accounted for
  - Multiple systems can be included

- This 8-card example:
  - Tracks 13,860,186 independent parts life history
  - Then we track at least 1000 system life histories to construct probability distributions
  - Takes about 100 min to run 1000 system life histories for the 8 board system

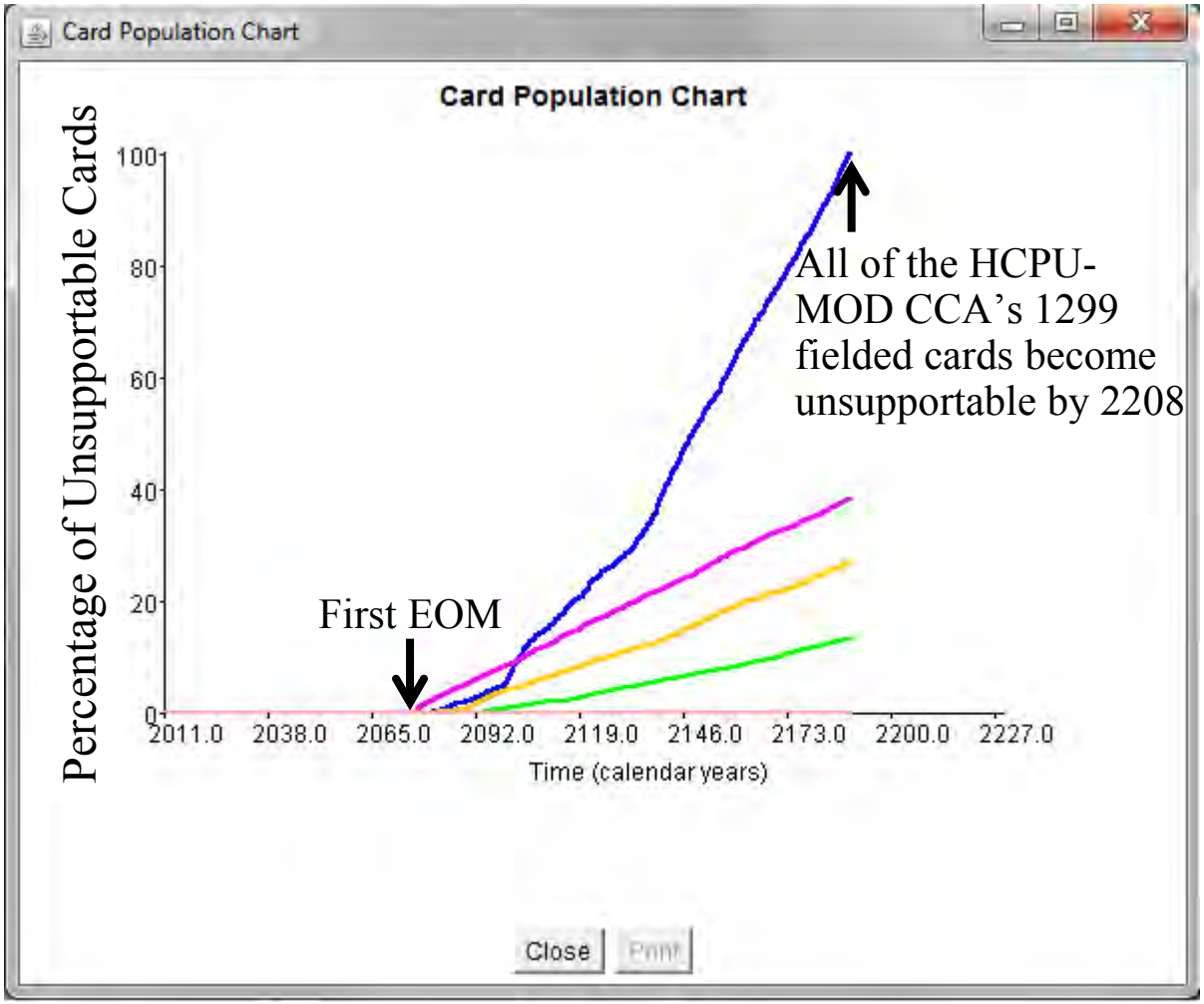
Demonstration (Outputs)





- Part 179732-001 causes the first EOM 92% of the time--card statistics below regard the first EOM
- SWITCH INTERFACE CCA is the card that can't be supported 92% of the time
- SBIU-MOD CCA is the card that can't be supported 5% of the time
- HCPU-MOD CCA is the card that can’t be supported 3% of the time

Demonstration (Outputs)



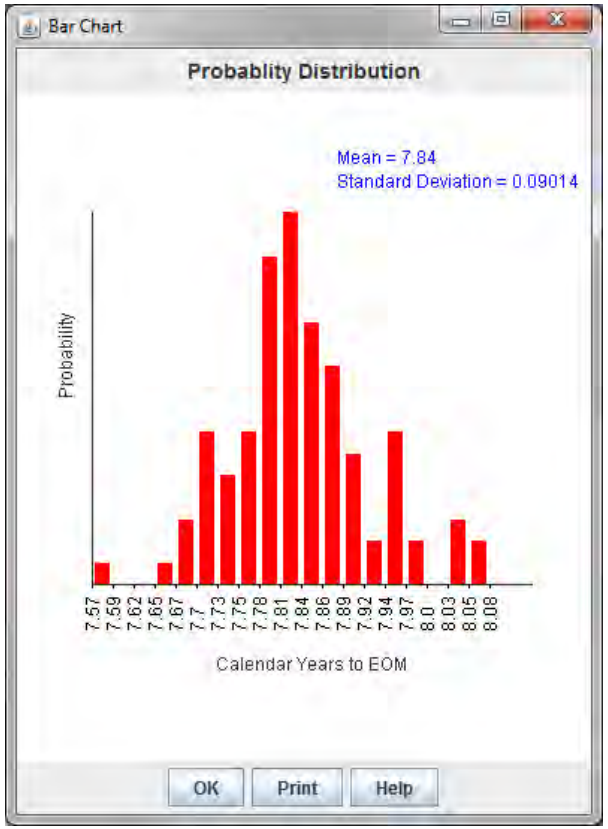
In 2208 (end of simulation):

CCA	Number of Unsupportable Cards
386 MAIN CCA (Green)	495
ANALOG MB/DB (Red)	0
HCPU-MOD CCA (Blue)	1299
LAN CCA (Black)	0
SBIU-MOD CCA (Orange)	506
SCLDU CCA (Cyan)	0
SWCH INT. CCA (Magenta)	1325
VIDEO CCA (Pink)	0

Yes, dates (200+ years) are unrealistic. This is because this is an abbreviated 8 card example drawing from an inventory that supports a larger card set.

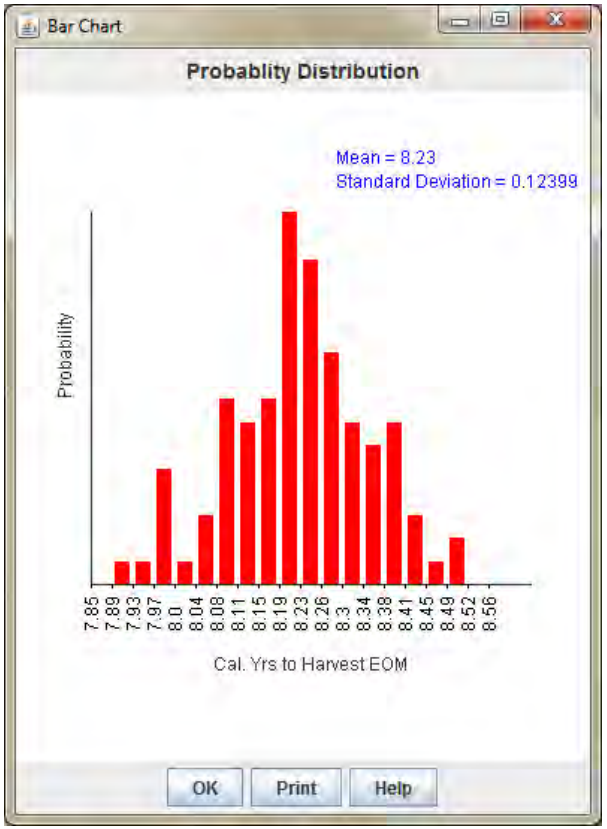
Demonstration – 78 Card System

No Harvesting



7.57-8.08 years to EOM

Harvested Parts from Scrapped Assemblies



7.85-8.56 years to EOM, gain ~0.5 year by harvesting

Key Assumptions:

- Existing inventories are not replenished
- Obsolete parts are not available from other sources
- Observed failure history is a good predictor of future sparing needs

Model Features
(Currently Supported)

- Multiple (segregated) inventories of new parts
- Cards can have spare inventories too
- Operates from failure distributions (user can define failure distributions)
- Part failure distributions can be card specific
- Synthesizing distributions from observed failures to date
- Shelf life (and other degradation in inventories)

But ....

There are lots of remaining problems that complicate this solution, including:

- Non-standard parts (we only treat standard parts today)
- Concurrent cost calculations
- How should parts with no failure history be treated?
- Replenishment of inventories via aftermarket sources
- Dependencies between parts, in some cases parts have to be replaced in groups (also “shot gunning”)

Summary

Quantitative (simulation-based) analysis of:

- The length of time that legacy inventories can be used to support an existing system
- Loss of support of a system over time

The analysis can also be reversed and used to forecast lifetime buy quantities (and associated confidence levels)